# Development of the Space Infrared Telescope Facility (SIRTF)

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## ABSTRACT

The Space Infrared Telescope Facility (SIRTF) is in the middle of the development phase and on track for a December, 2001 launch. This exciting mission takes advantage of innovative engineering choices to make groundbreaking science available in a cost-effective way. SIRTF, the fourth of NASA's Great Observatories, takes advantage of tremendous advances in infrared sensor technology as well as a high level of observatory efficiency in order to promise a rich scientific legacy.

The presentation provides an overview of the SIRTF Project and describes the Cryogenic Telescope, Science Instruments, and Spacecraft. In addition, investigation opportunities for the scientific community are described. A detailed report on the current status and future plans is also provided.

**Keywords:** SIRTF, infrared observatory, space telescope, infrared astronomy

## 1. MISSION DESCRIPTION

SIRTF is the fourth of NASA's Great Observatories. SIRTF imaging and spectroscopy in the infrared will complement the data acquired from the Hubble Space Telescope and the Chandra X-ray Observatory. SIRTF is on schedule to be launched in December 2001. The requirement is for a two and a half year mission with a goal of a five year mission. The Project has selected a Solar Orbit in which the observatory drifts away from the earth at 0.1 AU per year. This orbit was selected in order to improve observing efficiency, simplify observation planning, and remove the earth as a heat source for the observatory. The SIRTF Project is a collaborative effort between industry, academia and government.

## 2. OBSERVATORY DESCRIPTION

The Observatory is the space portion of the Facility, and is comprised of five major subsystems. There are three scientific instruments, the Cryogenic Telescope Assembly (CTA), and the Spacecraft.

SIRTF features an 85 cm aperture all beryllium telescope, which will be cooled to 5.5 K. The cryostat which houses the focal plane instruments will contain 360 liters of superfluid helium that will be expended over the life of the mission. SIRTF has a mass of about 900 kg and will be launched on a Delta 7920H launch vehicle. The observatory is shown in figure 1.

A unique feature of the observatory is the warm launch architecture. Previous infrared space telescope designs have enclosed both the telescope and instrument payload in the cryostat. In the case of SIRTF, only the science instruments are enclosed in the cryostat. This allows for significant reductions in both observatory mass and required cryogen. Passive cooling will allow the outer shell to cool to ~40 K. Cryogen boil off will cool both the outer cryostat tank and the telescope to ~5.5K, virtually eliminating any parasitic heat load on the cryogen once in space.

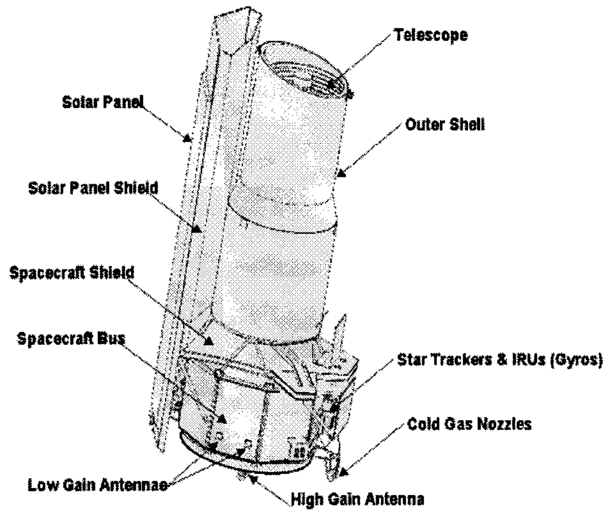


*Figure 1. The Space Infrared Telescope Facility (SIRTF)*

The three science instruments are the Infrared Array Camera (IRAC), the Multiband Imaging Photometer for SIRTF (MIPS), and the Infrared Spectrograph (IRS). Each instrument consists of a cold assembly located in the cryostat and a warm assembly located in the spacecraft. Below are descriptions of the three instruments, the CTA and the spacecraft.

**Infrared Array Camera (IRAC)**

The IRAC is a four-channel imager with the cold assembly packaged in a single module, providing images at 3.6 μm, 4.5 μm using Indium Antinomide (InSb) , and 5.8 μm, and 8.0 μm using Arsenic doped Silicon (Si:As) arrays. Each of the four are 256 x 256 pixel arrays. IRAC simultaneously views two adjacent 5.12 x 5.12 arc minute fields near the center of the telescope focal plane. Each of these fields are split into two channels by a dichroic beamsplitter, with the 3.6 μm and 5.8 μm channels in one field of view and the 4.5 μm and 8.0 μm channels in the other.

The IRAC instrument addresses two of the four major scientific objectives of the SIRTF mission. These objectives are the study of the formation and evolution of normal galaxies in the early Universe, and the study of the low end of the stellar luminosity function and the detection of brown dwarfs and superplanets.

**Multiband Imaging Photometer for SIRTF (MIPS)**

The MIPS instrument is designed to provide SIRTF with diffraction limited imaging capability with noise performance limited by natural sources over the wavelength and from 20 to 180 μm. In addition a low-resolution spectrometer provides spectral energy distribution measurements from 50 to 100 μm. MIPS employs three infrared detector arrays. A 128 x128 pixel Si:As device provides a spectral band at 24 μm, a 32 x 32 Gallium doped Germanium (Ge:Ga) photoconductor array provides a band at 70 μm, and a low resolution spectrometer. A 2 x 20 stressed Ge:Ga photoconductor array provides a band at 160 μm.

MIPS has been designed to carry out investigations in five key areas:

- efficient deep mapping and large field imaging in the three photometric bands
- photometry of point sources and compact sources in the three bands
- super resolution imaging in the three bands
- measurement of the spectral energy distributions at low spectral resolution of the 50-100 μm range
- measurement of total power by chopping against a cold reference

## Infrared Spectrograph (IRS)

The IRS provides SIRTF with low and moderate spectral resolution capabilities between 4 and 40 μm. The IRS is designed to perform diagnostic observations on previously known sources as well as on sources discovered by SIRTF.

In order to reduce the instrument development and testing costs, the IRS has no moving parts, employs simple flat gratings and surfaces of revolution in its optics, and has all aluminum optics, mounts, and housings. The cold assembly of the IRS is divided into four modules, each with its own pick-off mirror and detector array. All four detector arrays are 128 x 128 pixels in size and use blocked impurity band (BIB) conduction technology. The two shorter wavelength modules employ Si:As, and the longer wavelength modules employ Si:Sb. The IRS warm electronics are shared with the MIPS instrument in a common warm assembly.

## Cryogenic Telescope Assembly (CTA)

The Cryogenic Telescope Assembly is comprised of four key parts. The 85 cm Ritchey-Chretien Telescope, the superfluid helium cryostat, the outer shell group and the multiple instrument chamber (MIC) which houses the science instruments,. The telescope is cooled by helium vapor boil off from the cryostat due to the heat input from the instruments. Figure 2 shows the key elements of the Cryogenic Telescope Assembly. The CTA is mechanically mounted to, but thermally isolated from, the Spacecraft bus by means of low conductivity gamma-alumina struts. The solar panel, which is structurally cantilevered from the Spacecraft bus, shades the CTA from the sun at all times. The CTA is also thermally isolated from the solar panel and Spacecraft bus by means of low emissivity radiation shields.

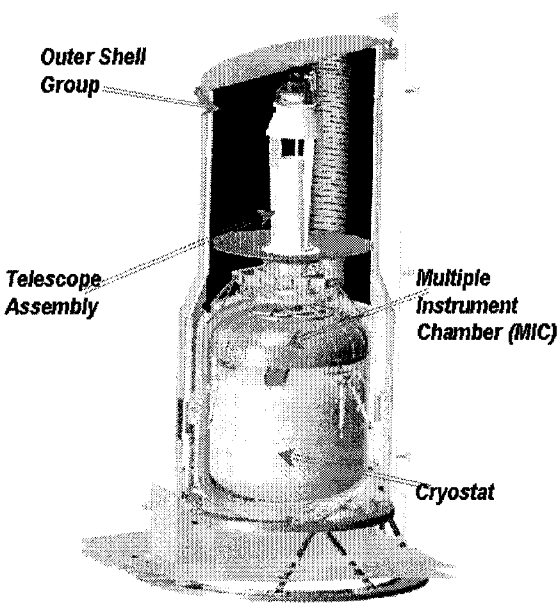


*Figure 2. Cryogenic Telescope Assembly*

## Spacecraft

The spacecraft provides electrical power, command and data handling, pointing control, thermal control, and communications with the ground as well as providing a stable structure for the CTA mounting surface. The spacecraft bus is comprised of nine bays in an octagonal configuration. The CTA mounts in eight locations on the upper deck of the Spacecraft. Heat pipes maintain a constant temperature across the mounting points. As shown in figure 3, the solar array is cantilevered from the bus. The deck is made of aluminum honeycomb sandwiched between composite face sheets. The spacecraft has dual string subsystems with cross strapping of major component.

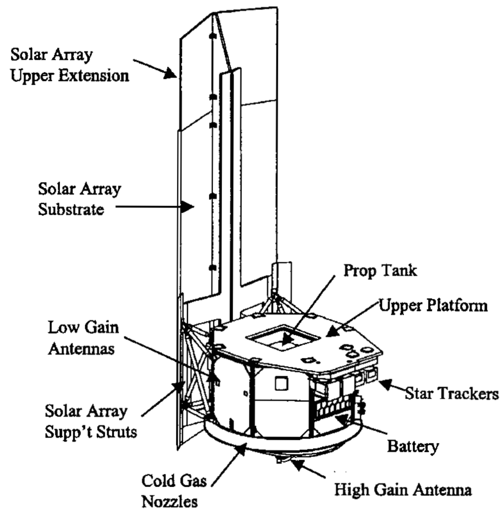


*Figure 3. Spacecraft*

## Project Status

At about 21 months before launch, progress on the completion of SIRTF hardware and software as well as launch readiness of the SIRTF mission continues to make good progress. The three science instruments are due to be delivered for integration into the CTA in April of 2000. Once the CTA is built up a cryogenic thermal vacuum performance test will be performed. In parallel with the integration and testing of the CTA, the spacecraft is also being integrated and tested. In February of 2001, the CTA and spacecraft will be integrated to form the Observatory. The remainder of time prior to the December, 2001 launch date will be dedicated to integration and test of the Observatory. In addition, this period of time will be used for ground system testing, training of the operations team, and other launch and operations preparations.

As discussed earlier, the CTA consists of the telescope, outer shell group, liquid helium cryostat, and multi-instrument chamber. The telescope primary and secondary mirrors, metering tower, and focus mechanism have all been completed. Alignment and cryogenic verification testing of the telescope are underway. The completed telescope is shown in figure 4.

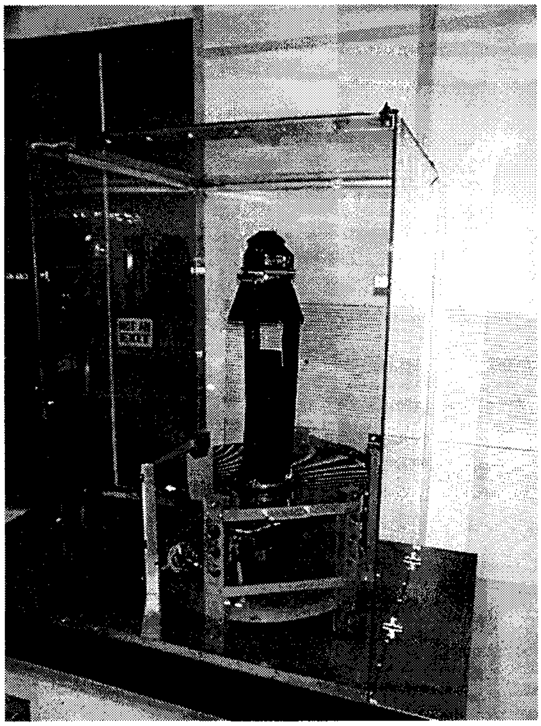

*Figure 4. Telescope*

The cryostat has also been completed, filled with liquid helium, and is undergoing performance testing. The cryostat is shown in figure 5. The outer shell group has also been completed and fit-checked and is shown in figure 6. The multi-instrument chamber is completed and awaiting the installation of the three science instruments and is shown in figure 7.

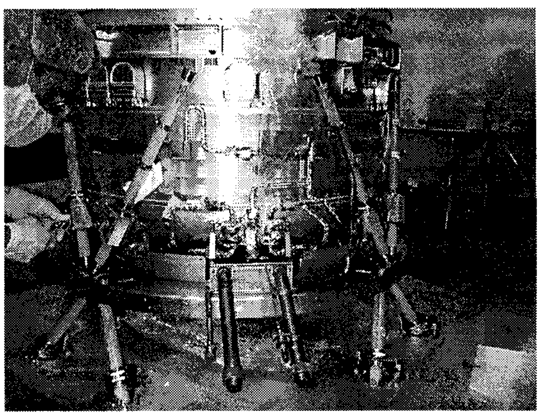

*Figure 5. Cryostat*

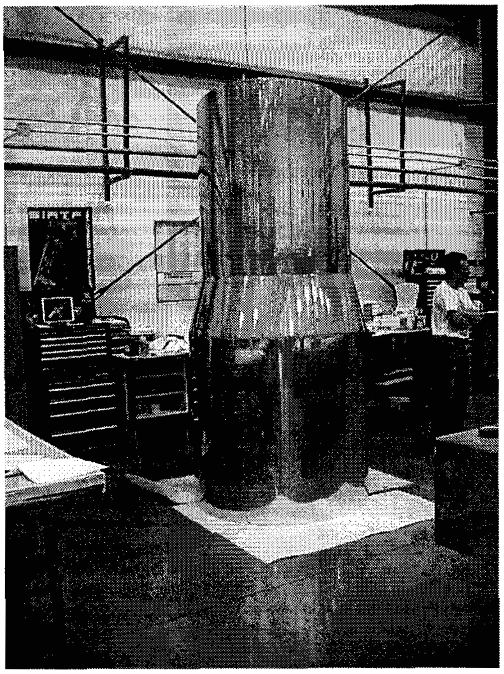

*Figure 6. Outer Shell Group*


*Figure 7. Multi-instrument Chamber*

The three scientific instruments are in the final stages of test and calibration prior to delivery to the CTA. It is critical that a comprehensive calibration database is acquired prior to delivery in order to streamline on-orbit activities. Access to the instruments will be extremely difficult once they are integrated into the multi-instrument chamber, which will in turn be integrated with the cryostat. The photographs below show the three scientific instruments.

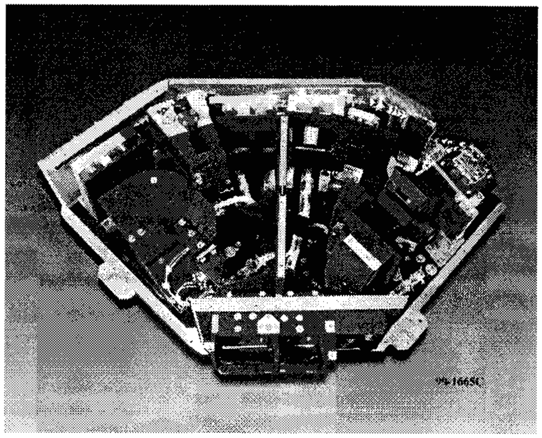

*Figure 8. Multiband Imaging Photometer for SIRTF (MIPS) Instrument*

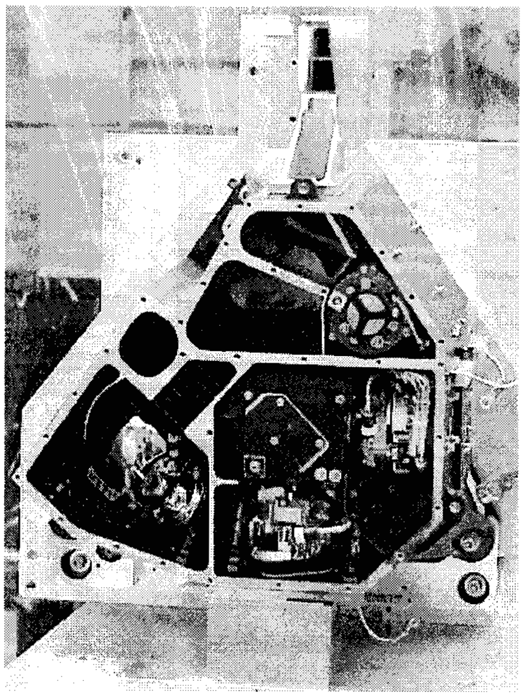

*Figure 9. Infrared Array Camera (IRAC) Instrument*

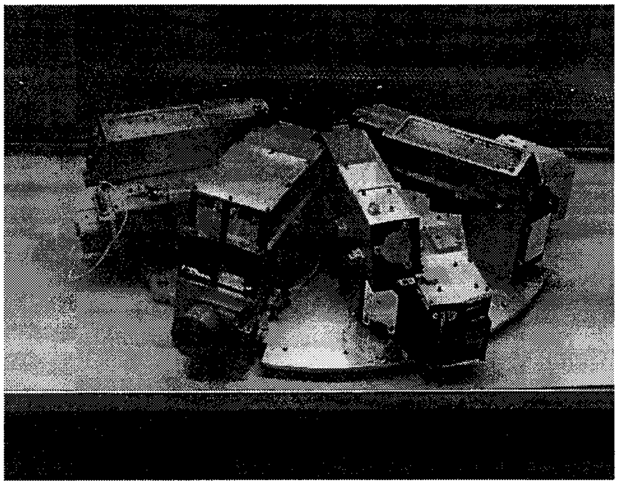

***Figure10. Infrared Spectrograph (IRS) Instrument***

The spacecraft bus structure has been completed and successfully passed through environmental testing including static and modal testing. Almost all of the spacecraft components have been delivered and integration will soon be underway. These include such things as gyros, reaction wheels, antennae, etc.
The star tracker will be one of the final components of the spacecraft to be delivered for integration. It is scheduled to be delivered in June, 2000. Photographs of the spacecraft bus are shown below in figures 11 and 12.

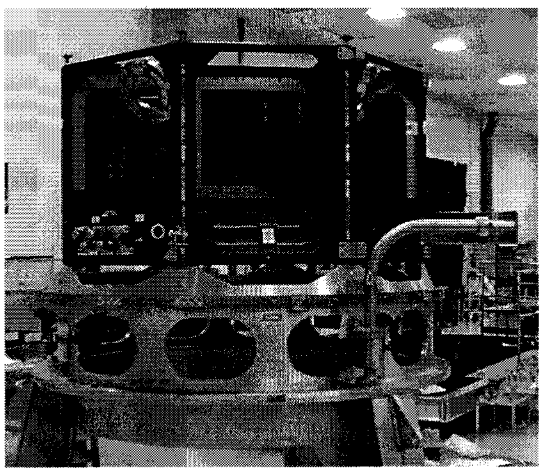

***Figure11. Spacecraft Bus – Equipment Section***

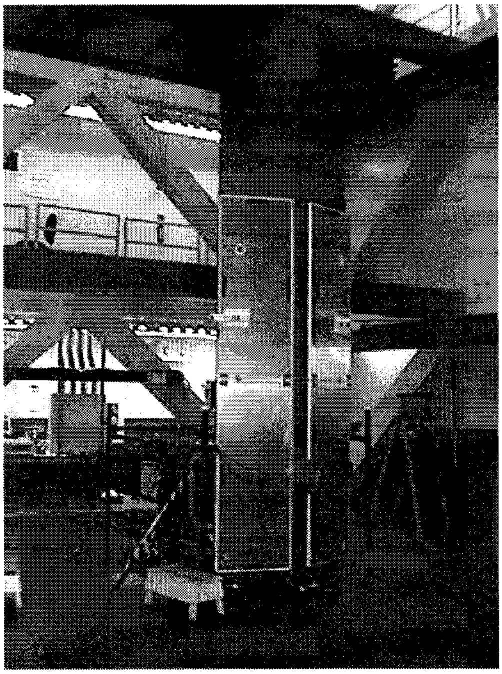

*Figure12. Spacecraft – Static Testing*

## 3. SCIENTIFIC OPPORTUNITIES USING SIRTF

It is a high priority to make SIRTF easily accessible to the science community. In fact, more than 75% of SIRTF observing time will be utilized by general observers in the science community. Observing proposals will be selected through a peer-reviewed proposal selection process. Participation by the international science community in encouraged and welcome.

There are two programs available to the science community interested in utilizing SIRTF. These are the Legacy Program and the General Observers Program. Legacy observations are distinguished from General Observations by the following three characteristics:

1. The project is a large, coherent investigation whose scientific goals cannot be met by a number of smaller, uncoordinated projects;

2. The data will be of both general and lasting importance to the broad astronomical community and of immediate utility in motivating and planning follow-on General Observer investigations with SIRTF;

3. The data will be placed in a public database immediately and with no community access restrictions.

One of the important aspects of the Legacy Program is the rapid population of a database with early scientific data, which can be drawn upon to develop follow-on proposals. The schedule of key events for those interested in utilizing SIRTF is shown below. All proposal preparation and submission activities will be carried out electronically.

Call for Legacy Proposals – July 2000
Selection of Legacy Science Teams – November 2000
First Call for General Observations – October 2001
SIRTF Launch – December 2001
Start Science Observations – February 2002
Responses due for first General Call – April 2002
Initiation of General Observer observations – August 2002
Second Call for General Observations – November 2002

| Current information on all aspects of the SIRTF Project can be found at http://sirtf.caltech.edu |
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## 4. ACKNOWLEDGEMENTS

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## 5. REFERENCES

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